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(54) **Title:** APPARATUS FOR EXHAUST WHIE POWDER ELIMINATION IN SUBSTRATE PROCESSING

(57) **Abstract:** Provided herein is a substrate processing system for semiconductor manufacturing. Such system comprises a process chamber; and exhaust system; and a means to provide cleaning gas. The exhaust systemcomprises a vacuum pump, a vacuum exhaust line, and a filtering apparatus installed downstream for the vacuum pump, a vacuum exhaust line, and a filtering apparatus installed downstream from the vacuum pump and within ghte vacuum exhaust line. Also provided is a method for eliminating or reducing solid residue accumulation in an exhaust line by introducing cleaning gas to the process chamber and further to the exhaust line; traffing solid residue by a filtering apparatus downstream for vacuum pump and within the exhaust line; trapping solid residue by a filtering apparatus downstream from vacuum pump and within the exhaust line; heating the filtering apparatus to re-activate the cleaning gas, which reacts with trapped solid residue and convert it to gaseous residue; and releasing the gaseous residue through the exhaust line.In-situ or remote plasma resource cleaning may be employed in conjunction with the above method.

APPARATUS FOR EXHAUST WHITE POWDER ELIMINATION IN SUBSTRATE PROCESSING

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to the field of substrate processing. More specifically, the present invention relates to an apparatus and/or process for removing solid residues (i.e., white powder) that accumulate in an exhaust line of a vacuum pump discharged during substrate processing.

Description of the Related Art

During typical substrate processing, deposition gas(es) inside a process chamber form a thin film layer on the surface of a substrate being processed. During the deposition, any remaining active chemical species and byproducts are pumped out of the chamber via a vacuum pump. The vacuum line is commonly referred to as the foreline.

Unconsumed gas molecules along with partially

reacted compounds and reaction byproducts are continuously pumped out of the process chamber through the foreline and out an exhaust output into a vacuum exhaust line. Effluent from the exhaust line is then either released as environmental emissions, or further treated using, for example, a scrubber, and then released.

Many of the compounds in the exhausted gas are still in highly reactive states and/or contain residues or particulate matter that can form unwanted deposits in the exhaust line. After a certain amount of time, this deposition build-up of powdery residue creates a significant problem. For example, when enough of this deposition material builds up in the exhaust line, the exhaust line begins to clog. Even if cleaned periodically, the build-up in the exhaust line nevertheless interferes with normal operation of the vacuum pump and can drastically shorten the useful life of the vacuum pump.

Thus, maintenance, repair or replacement of the vacuum pump are often required. Over time, the repair and replacement of the vacuum pump becomes very expensive and increases the cost of ownership of the equipment. Thus, the exhaust line typically needs to be cleaned at some point, depending on the type and number of deposition processes. Such cleaning requires the removal of the substrate processing system from the production stream, and can be very expensive in terms of lost production output.

In an attempt to avoid these problems, the inside surface of the foreline is cleaned regularly to remove the deposited material. This procedure is performed during a standard chamber cleaning operation that is employed to remove unwanted deposition material from the chamber walls and other areas of the chamber. Common chamber cleaning techniques include the use of an etching gas, such as fluorine or chlorine, to remove the deposited material from the chamber walls and other areas. In such a procedure, an etching gas is introduced into the chamber and a plasma is formed so that the etching gas reacts with and further removes the deposited material from the chamber walls. These cleaning procedures are performed commonly between deposition steps for every substrate or every N substrates.

Removal of deposition material from chamber walls is relatively straightforward in that the plasma is created within the chamber in an area proximate to the deposited material. Removal of deposition material from the foreline has also not raised serious issues due to increased temperatures used during semiconductor processing. However, removal of deposition material from the exhaust line has proven more difficult because the exhaust line is downstream from the vacuum pump. Thus, in a fixed time period, although the chamber and the foreline may be adequately cleaned, residue and similar deposits nevertheless remain in the exhaust line.

One prior attempt to adequately clean the exhaust

line included increasing the duration of the cleaning operation. Increasing the length of the cleaning operation, however, is undesirable because it adversely effects substrate throughput. Also, such residue build-up can be cleaned only to the extent that reactants from the cleaning step are exhausted into the exhaust line in a state that they may react with the residues in the exhaust line. In some systems and applications, the lifetime of the exhausted reactants is not sufficient to reach the exhaust line, which makes residue build-up even more of a concern.

Raoux et al. (*Plasma Sources Sci. Technol.,* 6:405-414, 1997) introduced a plasma cleaning apparatus (DPA) trap installed in communication with the foreline between the process chamber and the vacuum pump that traps the particles by electrostatic potential and removes the particles by plasma inside the trap.

Other attempts to remove unwanted deposition included heating the entire exhaust pipe to a set temperature. Unfortunately, heating at high temperature suffers from a number of drawbacks. For example, the combustion forms a very fine powder that can clog the system. In addition, the particles are generally collected by water scrubbing, and the scrubbing water itself must be treated prior to disposal to remove the particles as well as water-soluble contaminants.

Therefore, the prior art is deficient in the lack of effective means for eliminating or reducing contamination and

residues (white powder) from an exhaust line connected downstream from a vacuum pump. The present invention fulfills these long-standing needs and desires in the art.

SUMMARY OF THE INVENTION

In general, the present invention provides a system and methodology configured to minimize the deposition of solid residues in a vacuum pump exhaust line.

Provided herein in one embodiment of the present invention is a substrate processing system for substrate manufacturing. This system comprises a process chamber; an exhaust system; and a means to provide a cleaning gas to the process chamber. The exhaust system comprises a vacuum pump, a vacuum exhaust line, and a filtering apparatus installed downstream from the vacuum pump and within the vacuum exhaust line.

Also provided in another embodiment of the present invention is a method for eliminating or reducing solid residues accumulation in an exhaust line of a substrate processing system. This method comprises the steps of: (1) introducing at least one cleaning gas to the process chamber and which further flows to the exhaust line; (2) trapping solid residues produced during substrate processing, wherein the residues are trapped in or

filtered by a filtering apparatus downstream from the vacuum pump and within the exhaust line; (3) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues thus converting said solid residues to gaseous residue; and (4) releasing the gaseous residues through the exhaust line, therefore generally eliminating or reducing solid residue accumulation from the exhaust line.

Alternatively, also provided in another embodiment of the present invention is a method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, comprising the steps of: (1) introducing at least one precursor gas to the process chamber of the substrate processing system; (2) applying a plasma locally to the precursor gas, wherein the plasma activates the precursor gas to form a plasma of cleaning gas, which further flows to the exhaust line; (3) trapping solid residues produced during substrate processing, wherein the residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line; (4) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues thus converting said solid residues to gaseous residues; and (5) releasing the gaseous residues through the exhaust line, therefore generally eliminating solid residue accumulation from the exhaust line.

Alternatively, provided in another embodiment of the present invention, is a method for eliminating or reducing solid

residue accumulation in an exhaust line of a substrate processing system, comprising the steps of: (1) introducing at least one precursor gas to a remote chamber, wherein said remote chamber is connected to the interior of the process chamber of the substrate processing system; (2) activating the precursor gas in the remote chamber, thereby forming a plasma of cleaning gas; (3) introducing the plasma of cleaning gas to the process chamber, wherein said plasma of cleaning gas further flows to the exhaust line; (4) trapping solid residues produced during substrate processing, wherein the residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line; (5) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues thus converting said solid residues to gaseous residues; and (6) releasing the gaseous residues through the exhaust line, therefore generally eliminating solid residue accumulation from the exhaust line.

Other and further aspects, features, and advantages of the present invention will be apparent from the following description of the embodiments of the invention given for the purpose of disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the matter in which the above-recited features, advantages and objects of the invention, as well as others which will become clear, are attained and can be understood in detail, more particular descriptions of the invention briefly summarized above may be had by reference to certain embodiments thereof which are illustrated in the appended drawings. These drawings form a part of the specification. It is to be noted, however, that the appended drawings illustrate embodiments of the invention and therefore are not to be considered limiting in their scope.

Figure 1 is a schematic drawing of the filtering apparatus **100** in accordance with one embodiment of the invention. The apparatus **100** comprises heater **101**, CAP white particle filter **102**, "O" rings **103**, spool **104**, filter discs **105**, and spacer **106**.

Figure 2 is a schematic drawing illustrating one aspect of the invention. More specifically, **Figure 2** shows that a cleaning gas is introduced into the process chamber and further directed to the filtering apparatus of the invention.

Figure 3 is a schematic drawing illustrating one embodiment of the invention, that is, a remote plasma source is employed in conjunction with the filtering apparatus of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides, in part, a filtering apparatus, referred to herein as an Exhaust White Powder Eliminator or Annihilator, that can be used for substantially preventing solid residue(s) from building up and significantly impeding the exhaust line of a substrate process chamber.

During substrate processing operations, such as a flat panel display (FPD) process, a variety of gaseous waste products and contaminants are exhausted from the chamber into the vacuum manifold. Depending on the particular operation being performed, these exhaust products may include partially reacted products and/or byproducts that leave a residue or similar powdery material in the exhaust line. The filtering apparatus of the present invention prevents build-up of such particulate matter in the exhaust line. This filtering apparatus is positioned downstream from the vacuum pump within the exhaust line. The apparatus may either connect to or replace a portion of the exhaust output, which is located downstream from the vacuum pump. Gases containing solid residues and exhausted from the process chamber subsequently pass through the filtering apparatus, wherein the solid residues are trapped. Upon heating, the trapped solid residues are removed by a cleaning gas flowing to the filtering apparatus during chamber cleaning cycle.

It is possible to connect two or more filtering

apparatuses to the exhaust output. Such a configuration might be used, for example, to employ two filtering apparatuses optimized for particle collection to further protect the exhaust line from particle and residue build-up.

The apparatus of the present invention can be used in conjunction with any variety of substrate processing methods that produce detrimental by-products, such as a flat panel display (FPD) processes, chemical vapor deposition processes such as a plasma-enhanced chemical vapor deposition process or PECVD process, etch processes, or thermal processes.

Therefore, as described above, one aspect of the invention is a substrate processing system for semiconductor manufacturing. This system comprises a process chamber; an exhaust system; and a means to provide a cleaning gas to the process chamber. The exhaust system comprises a vacuum pump, a vacuum exhaust line, and a filtering apparatus installed downstream from the vacuum pump and within the vacuum exhaust line. The filtering apparatus traps the solid residues. At elevated temperatures, the trapped solid residue is removed by the cleaning gas flowing to the exhaust line, therefore solid residues accumulating in the vacuum exhaust line is reduced or prevented.

Specifically, the filtering apparatus is an enclosed system comprising one or more filter discs, a heater, and a conduit enclosing the heater. The filter discs are sealably

disposed within walls of the enclosed system and walls of the heater conduit. More specifically, the filter disc has a filter hole of a size small enough to trap the solid residues. For example, the filter disc may have a filter hole of a size from about 10 μm to about 30 μm. In the case of multiple filter discs being used, the discs are arranged in such a way that the disc having a larger filter hole is disposed upstream of the disc having a smaller filter hole.

More specifically, the process chamber can be a flat panel display (FPD) chamber or a semiconductor process chamber (e.g., PECVD chamber or an etch process chamber). Representative examples of solid residue which would be filtered by the filtering apparatus of the invention include SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, and their adsorbents, such as SiH.sub.4, NH.sub.3 and HF. The cleaning gas may be a fluorine-containing gas, a chlorine-containing gas or a halogen-containing gas. Representative examples of fluorine-containing gas include HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

In another aspect, there is provided a method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system. This method comprises the steps of: (1) introducing at least one cleaning gas to the process chamber and which further flows to the exhaust line; (2) trapping solid residues produced during substrate processing, wherein the residues are trapped in or filtered by a filtering apparatus

downstream from vacuum pump and within the exhaust line; (3) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues, which is in turn converted to gaseous residues; and (4) releasing the gaseous residues through the exhaust line, therefore reducing and generally eliminating solid residues accumulation from the exhaust line.

Specifically, the filtering apparatus is heated to a temperature of from about 100°C to about 250°C. The process chamber can be a flat panel display (FPD) chamber, a CVD chamber, an etch process chamber or a thermal process chamber. Representative examples of solid residues which could be filtered by the filtering apparatus of the invention include SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, and their adsorbents, such as SiH.sub.4, NH.sub.3 and HF. The cleaning gas may be a fluorine-containing gas, a chlorine-containing gas or a halogen-containing gas. Representative examples of fluorine-containing gas include HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

In still another aspect of the present invention, there is provided a method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, which comprises the steps of: (1) introducing at least one precursor gas to the process chamber of the substrate processing system; (2) applying a plasma locally to the precursor gas, wherein the plasma activates the precursor gas to form a plasma

of cleaning gas, which further flows to the exhaust line of the substrate processing system; (3) trapping solid residues produced during substrate processing, wherein the residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line; (4) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues, which are in turn converted to gaseous residues; and (5) releasing the gaseous residues through the exhaust line, therefore generally eliminating solid residue accumulation from the exhaust line.

Specifically, the filtering apparatus may be heated to a temperature of from about 100°C to about 250°C. The process chamber can be a flat panel display (FPD) chamber, a CVD chamber, an etch process chamber or a thermal process chamber. Representative examples of solid residues which could be filtered by the filtering apparatus of the invention include SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, and their adsorbents, such as SiH.sub.4, NH.sub.3 and HF. The cleaning gas may be a fluorine-containing gas, a chlorine-containing gas or a halogen-containing gas. Representative examples of fluorine-containing gas include HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

In yet another aspect, there is provided a method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, which comprises the steps of: (1) introducing at least one precursor gas to a remote

chamber, which is connected to the interior of the process chamber of the substrate processing system; (2) activating the precursor gas in the remote chamber, thereby forming a plasma of cleaning gas; (3) applying the plasma of cleaning gas to the process chamber, which further flows to the exhaust line; (4) trapping solid residues produced during substrate processing, wherein the residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line; (5) heating the filtering apparatus, wherein the cleaning gas is re-activated and further reacts with trapped solid residues thus converting said solid residues to gaseous residues; and (6) releasing the gaseous residues through the exhaust line, therefore generally eliminating solid residue accumulation from the exhaust line.

Specifically, the filtering apparatus is heated to a temperature of from about 100°C to about 250°C. The process chamber can be a flat panel display (FPD) chamber, a CVD chamber, an etch process chamber or a thermal process chamber. Representative examples of solid residues which could be filtered by the filtering apparatus of the invention include SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, and their adsorbents, such as SiH.sub.4, NH.sub.3 and HF. The cleaning gas may be a fluorine-containing gas, a chlorine-containing gas or a halogen-containing gas. Representative examples of fluorine-containing gas include HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

The following examples are given for the purpose of illustrating various embodiments of the invention and are not meant to limit the present invention in any fashion.

EXAMPLE 1

Exhaust White Powder Eliminator

The filtering apparatus (referred herein as Annihilator, or Exhaust White Powder Eliminator) of the invention is installed at the exhaust output of the vacuum pump, which in turn is attached to a flat panel display (FPD) process chamber or a semiconductor processing system. Referring to Figure 1, filtering apparatus **100** is an enclosed system with a first connection to the upstream vacuum pump and second connection to the exhaust system. The apparatus comprises heater **101**, CAP white particle filter **102**, "O" rings **103**, spool **104**, filter discs **105**, and spacer **106**. The heater **101** is sealed in a conduit without exposure to the cleaning gas flowing into the filtering enclosure. During the cleaning cycle, the cleaning gas flows into this filtering enclosure from the upstream vacuum pump, passes through the filter discs, wherein re-activation of the cleaning gas occurs, and the final products are released into the exhaust system.

The filter assembly comprises one or more discs, which are sealably disposed within internal wall of the filtering enclosure and the wall of the heater conduit. Each disc provides

a round of filtering activity. The disc in the upstream of the gas flow usually has larger filter holes compared to the one in the downstream. Filter disc with larger holes filters through large particles, which subsequently pass through the disc(s) in the downstream, wherein only fine particles can be filtered through. Discs with smaller holes are better in providing higher filtering efficiency; however, they reduce the gas conductance which could affect the pumping speed.

Referring to Figure 1, an example of a three-stage particle filter is illustrated. Three filter discs provide a three-stage filtering to obtain high trapping efficiency. The filter holes for the two discs in the upstream can be, e.g., about 30 μm, while the third disc has, e.g., filter holes of about 10 μm.

Materials useful in constructing the filter are generally any materials that can sustain a corrosive environment. For example, the filter maybe one or more discs made of porous aluminum or ceramic (Al_2O_3 or AlN) to be compatible with high temperature fluorine etch environment.

<u>EXAMPLE 2</u>

<u>Deposition and Cleaning Process in Conjunction with the Exhaust White Powder Eliminator</u>

During the deposition process, the dielectric (SiOx, SiNx, SiOxNy, etc) or the semiconductor (α-Si, p-Si, etc.) CVD films

are deposited on the substrate. During the cleaning process, cleaning gas is constantly flown to the chamber. Fluorine-containing gas, chlorine-containing gas or halogen-containing gas may be used as the cleaning gas. For example, fluorine-containing gas such as F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6 or CF.sub.4 is commonly used for cleaning.

Figure 2 illustrates one aspect of the invention, wherein the cleaning gas is introduced into the process chamber, and further directed to the filtering apparatus of the invention for removing the white powder accumulation from the exhaust line downstream of the pump.

In-situ plasma cleaning may be employed for the dissociation of cleaning gas. In such systems, precursor gases are supplied to the chamber. Then, by locally applying a glow discharge plasma to the precursor gases within the chamber, reactive species are generated. The reactive species clean the chamber surfaces by forming volatile compounds with the process residues on those surfaces.

Alternatively, the plasma may be provided remotely. A remote plasma source cleaning system comprises a cleaning gas source connected to a remote activation chamber. The cleaning gas source includes a source of a precursor gas, an electronically-operated valve and flow control mechanism for controlling the flow of precursor gas and a conduit for flowing the gas into the remote activation chamber located outside and at a distance from

the process chamber. A power activation source, for example a high-power microwave generator, is used to activate the precursor gas within the remote activation chamber. The remote chamber may be a sapphire tube and the power source a 2.54 GHz microwave energy source with its output aimed at the sapphire tube. The precursor gas may be a fluorine-containing gas, chlorine-containing gas or halogen-containing gas, for example, NF.sub.3. The flow rate of activated species is about 2 liters per minute and the process chamber pressure is about 0.5 Torr. To activate the precursor gas, the microwave source delivers about 3,000-12,000 Watts to the remote activation chamber. A value of 5,000 Watts may be used for many applications. Upon activation, a plasma of cleaning gas is generated in the remote chamber, and a portion of the plasma is then introduced into the process chamber.

Figure 3 illustrates another aspect of the invention, wherein a remote plasma source is employed for cleaning the process chamber, and the cleaning gas is further directed to the filtering apparatus of the invention for removing the white powder accumulation from the exhaust line downstream of the pump.

During substrate processing operations, a variety of gaseous waste products and contaminants are exhausted from the process chamber into the vacuum manifold. Depending on the particular operation being performed, these exhaust products may include partially reacted products and/or byproducts that

leave a residue or similar powdery material in the exhaust line. Using the filtering apparatus of the present invention, particles are trapped by the particle filter disc(s) inside the device. The remaining unused cleaning gas, e.g., F2 or F, flows to the exhaust line during the cleaning cycle. The filtering apparatus is heated to a temperature of about 100-250°C. At such elevated temperature, the cleaning gas is re-activated so that it may react with the solid residues, which are in turn converted to gaseous state. For example, solid residue, such as SiN reacts with the cleaning gas, such as F2 or F via the following equation:

$$SiN\ (solid) + F\ (F2) \rightarrow SiF4\ (gas)$$

The converted gaseous residue is then pumped away. As can be observed visually, the trap and self-clean methodology of the invention reduces the white powder inside the exhaust line.

EXAMPLE 3

Application of Exhaust White Powder Eliminator

One example of a use of a technique and apparatus of the present invention is in AKT PECVD systems, where after CVD silane processes (oxides, nitrides and amorphous silicon), the chamber needs to be periodically cleaned. The solid residue (white powder) accumulates inside the exhaust line of the vacuum pump and creates high-pressure build-up in the exhaust line. The vacuum pump thus fails due to this high pressure in the exhaust line. The solid residue reduces the diameter of the exhaust pipe, or even clogs the exhaust line completely. The

solid residue also reduces the lifetime of the vacuum pump. Examples of unwanted solid residues generally include SiN, SiO, α-Si, $(NH_4)_2SiF_6$, NH_4F, SiH_4, NH_3, and HF. By installing Exhaust White Powder Eliminator on the exhaust output of the vacuum pump, white powder is trapped and eliminated inside the filter enclosure. Such process extends the vacuum pump lifetime, largely reduces system downtime and significantly reduces the maintenance cost.

In conclusion, the filtering apparatus of the present invention uses existing chamber resources and a re-activation means (e.g., heating) to clean the exhaust line of a substrate process chamber. Compared to the prior-art cleaning device (e.g., Raoux's plasma cleaning apparatus (DPA)), the presently disclosed filtering apparatus has the following advantages: Raoux's DPA is mounted in the chamber foreline, which affects the pump performance. To operate the DPA, substantial control systems are needed, such as additional plasma source and electrostatic potential. In contrast, the filtering apparatus is much simpler: no additional plasma is applied to the exhaust line; no additional gas is required for the cleaning; and low or no maintenance is required. Since such filtering apparatus is mounted downstream of the pump and within the exhaust line, the pump performance is not affected.

One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. It will be apparent to those skilled in the art

that various modifications and variations can be made in practicing the present invention without departing from the spirit or scope of the invention. Changes therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention as defined by the scope of the claims.

WHAT IS CLAIMED IS:

1. A substrate processing system, comprising:

a process chamber;

an exhaust system, wherein said exhaust system comprises:

a vacuum pump,

a vacuum exhaust line, and

a filtering apparatus, wherein said filtering apparatus is installed downstream from said vacuum pump and within said vacuum exhaust line; and

a means to provide at least one cleaning gas to the process chamber.

2. The substrate processing system of claim 1, wherein said process chamber is selected from the group consisting of a flat panel display chamber and a semiconductor process chamber.

3. The substrate processing system of claim 2, wherein said semiconductor process chamber is selected from the group consisting of a chemical vapor deposition chamber and an etch process chamber.

4. The substrate processing system of claim 1,

wherein said filtering apparatus is an enclosed system comprising one or more filter discs, a heater, and a conduit enclosing said heater, wherein said filter disc is sealably disposed within walls of the enclosed system and walls of said conduit.

5. The substrate processing system of claim 4, wherein said filter disc has filter holes of from about 10 μm to about 30 μm.

6. The substrate processing system of claim 4, wherein said filter discs are arranged such that the disc having a larger filter hole is disposed upstream of the disc having a smaller filter hole.

7. The substrate processing system of claim 1, wherein said filtering apparatus prevents or reduces solid residues from accumulating in said vacuum exhaust line.

8. The substrate processing system of claim 7, wherein said filtering apparatus traps the solid residues.

9. The substrate processing system of claim 7, wherein said solid residue is selected from the group consisting of

SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, SiH.sub.4, NH.sub.3 and HF.

10. The substrate processing system of claim 1, wherein said cleaning gas is selected from the group consisting of a fluorine-containing gas, a chlorine-containing gas, and a halogen-containing gas.

11. The substrate processing system of claim 10, wherein said fluorine-containing gas is selected from the group consisting of HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

12. A method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, comprising the steps of:

introducing at least one cleaning gas to the process chamber, wherein said cleaning gas further flows to the exhaust line;

trapping solid residues produced during substrate processing, wherein said residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line;

heating said filtering apparatus, wherein said cleaning gas is re-activated and further reacts with trapped solid residues,

thereby converting said solid residues to gaseous residues; and

releasing said gaseous residues through the exhaust line, so that solid residue accumulation is eliminated or reduced in said exhaust line.

13. The method of claim 12, wherein said solid residues are selected from the group consisting of SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, SiH.sub.4, NH.sub.3 and HF.

14. The method of claim 12, wherein said cleaning gas is selected from the group consisting of a fluorine-containing gas, a chlorine-containing gas, and a halogen-containing gas.

15. The method of claim 14, wherein said fluorine-containing gas is selected from the group consisting of HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

16. The method of claim 12, wherein said process chamber is selected from the group consisting of a flat panel display chamber and a semiconductor process chamber.

17. The method of claim 16, wherein said

semiconductor process chamber is selected from the group consisting of a chemical vapor deposition chamber and an etch process chamber.

18. The method of claim 12, wherein said filtering apparatus is heated to a temperature of from about 100°C to about 250°C.

19. A method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, comprising the steps of:

introducing at least one precursor gas to the process chamber of said substrate processing system;

applying a plasma to said precursor gas in said process chamber, wherein said plasma activates said precursor gas to form a plasma of cleaning gas, and wherein said cleaning gas further flows to the exhaust line;

trapping solid residues produced during substrate processing, wherein said residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line;

heating said filtering apparatus, wherein said cleaning gas is re-activated and further reacts with trapped solid residues, thereby converting said solid residues to gaseous residues; and

releasing said gaseous residues through the exhaust line, so that solid residue accumulation is eliminated or reduced

in said exhaust line.

20. The method of claim 19, wherein said solid residues are selected from the group consisting of SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, SiH.sub.4, NH.sub.3 and HF.

21. The method of claim 19, wherein said cleaning gas is selected from the group consisting of a fluorine-containing gas, a chlorine-containing gas, and a halogen-containing gas.

22. The method of claim 21, wherein said fluorine-containing gas is selected from the group consisting of HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

23. The method of claim 19, wherein said process chamber is selected from the group consisting of a flat panel display chamber and a semiconductor process chamber.

24. The method of claim 23, wherein said semiconductor process chamber is selected from the group consisting of a chemical vapor deposition chamber and an etch process chamber.

25. The method of claim 19, wherein said filtering apparatus is heated to a temperature of from about 100°C to about 250°C.

26. A method for eliminating or reducing solid residue accumulation in an exhaust line of a substrate processing system, comprising the steps of:

introducing at least one precursor gas to a remote chamber, wherein said remote chamber is connected to the interior of the process chamber of said substrate processing system;

activating said precursor gas in said remote chamber, thereby forming a plasma of cleaning gas;

applying said plasma of cleaning gas to said process chamber, wherein said cleaning gas further flows to the exhaust line;

trapping solid residues produced during substrate processing, wherein said residues are trapped in or filtered by a filtering apparatus downstream from vacuum pump and within the exhaust line;

heating said filtering apparatus, wherein said cleaning gas is re-activated and further reacts with trapped solid residues, thereby converting said solid residues to gaseous residues; and

releasing said gaseous residues through the exhaust line, so that solid residue accumulation is eliminated or reduced in said exhaust line.

27. The method of claim 26, wherein said solid residue is selected from the group consisting of SiN, SiO, α-Si, (NH.sub.4).sub.2SiF.sub.6, NH.sub.4F, SiH.sub.4, NH.sub.3 and HF.

28. The method of claim 26, wherein said cleaning gas is selected from the group consisting of a fluorine-containing gas, a chlorine-containing gas, and a halogen-containing gas.

29. The method of claim 28, wherein said fluorine-containing gas is selected from the group consisting of HF, F.sub.2, NF.sub.3, SF.sub.6, C.sub.2 F.sub.6, CF.sub.4, C.sub.3F.sub.8O, and C.sub.xF.sub.y.

30. The method of claim 26, wherein said process chamber is selected from the group consisting of a flat panel display chamber and a semiconductor process chamber.

31. The method of claim 30, wherein said semiconductor process chamber is selected from the group consisting of a chemical vapor deposition chamber and an etch process chamber.

32. The method of claim 26, wherein said filtering apparatus is heated to a temperature of from about 100°C to about 250°C.

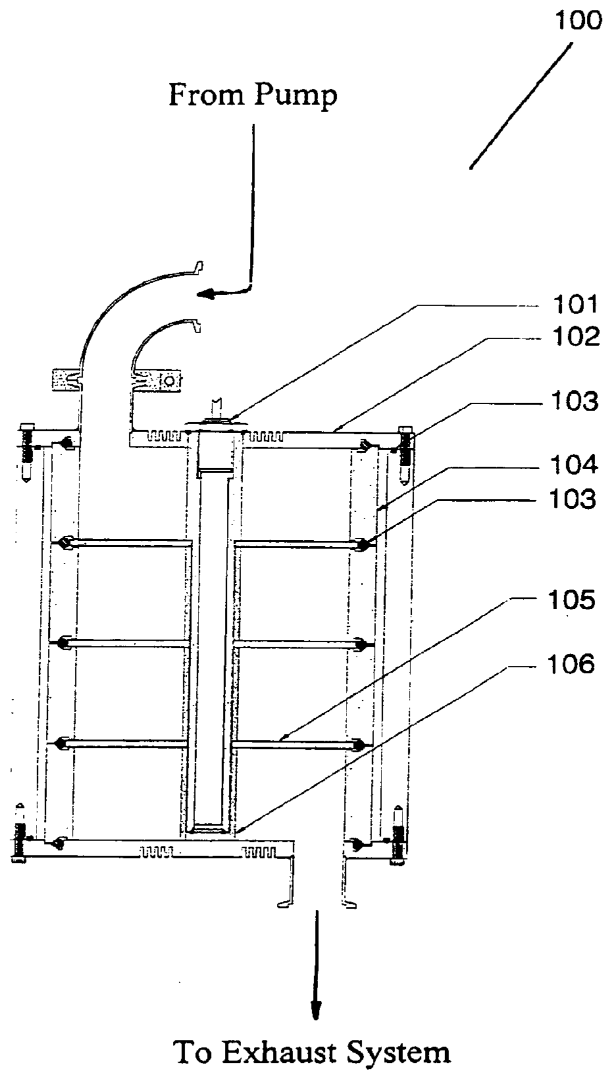

FIG. 1

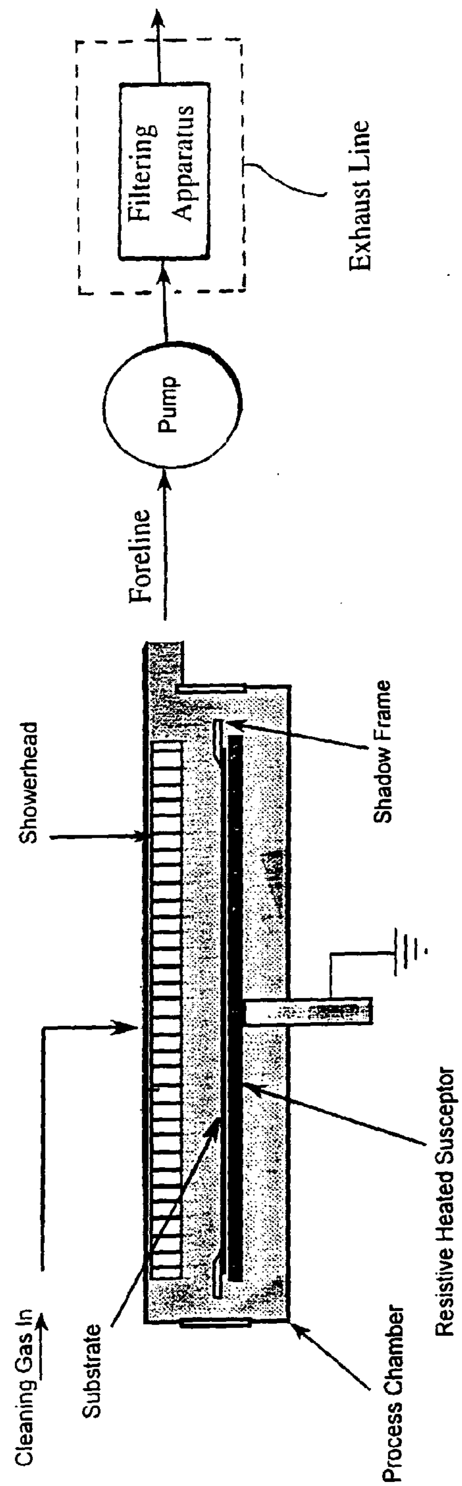
Filtering Apparatus
Exhaust Line
Pump
Foreline
Showerhead
Shadow Frame
Cleaning Gas In
Substrate
Resistive Heated Susceptor
Process Chamber

FIG. 2

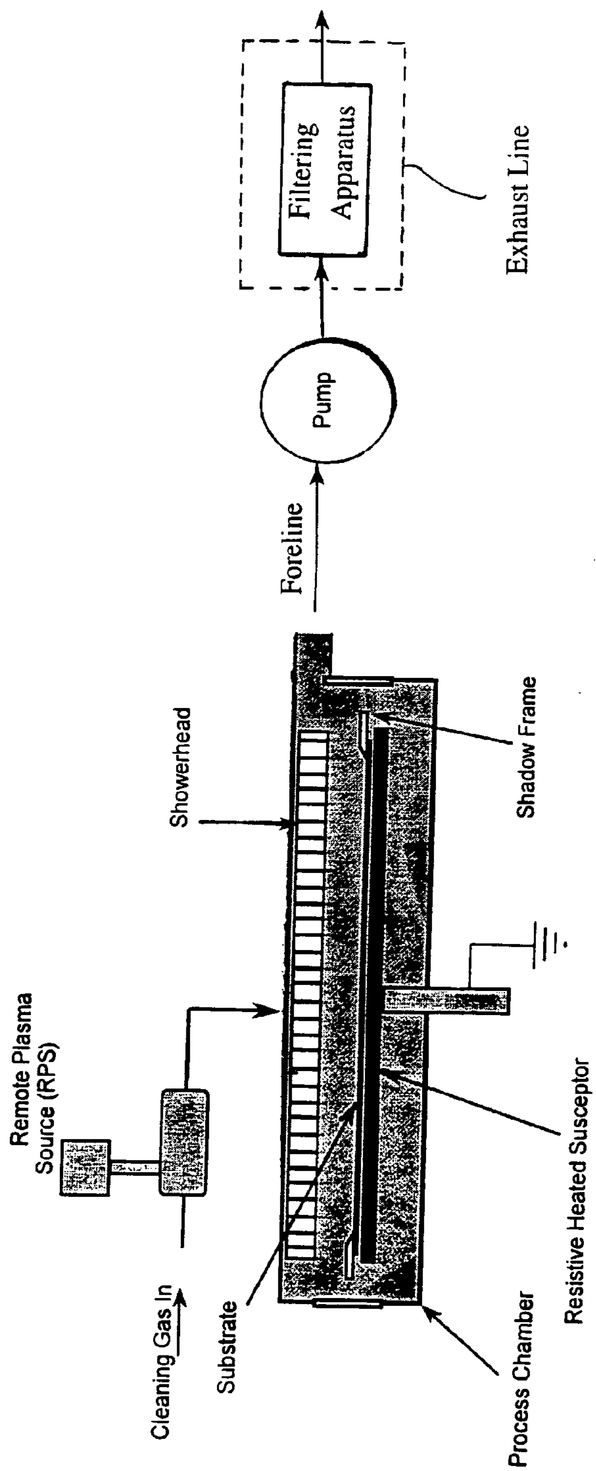
Remote Plasma Source (RPS)
Cleaning Gas In
Showerhead
Substrate
Process Chamber
Resistive Heated Susceptor
Shadow Frame
Foreline
Pump
Filtering Apparatus
Exhaust Line

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/50617

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C23C16/44 C23F4/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C23C H01J H01L C23F B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 655 800 A (TSUKADA TSUTOMU ET AL) 7 April 1987 (1987-04-07) column 4, line 3 -column 5, line 60; figure 2	1-3,7,8, 10
X	EP 0 823 279 A (NOVELLUS SYSTEMS INC) 11 February 1998 (1998-02-11) page 4, line 9 -page 5, line 13; figure 1	1-3
X	US 5 951 772 A (TANAKA SUMI ET AL) 14 September 1999 (1999-09-14)	1-3,10
A	column 6, line 1 -column 11, line 38; figure 1	12-32

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2002	13/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Patterson, A

Int onal Application No
PCT/US 01/50617

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	RAOUX S ET AL: "GROWTH, TRAPPING AND ABATEMENT OF DIELECTRIC PARTICLES IN PECVD SYSTEMS" PLASMA SOURCES SCIENCE AND TECHNOLOGY, IOP PUBLISHING LTD, XX, vol. 6, 1997, pages 405-414, XP000669756 ISSN: 0963-0252 cited in the application the whole document -----	1-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/50617

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